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LETTERS TO THE EDITOR.

Magnetic Storms and their Astronomical Effects.

THE earth is sometimes spoken of as a great magnet. Its magnetic condition, however, is not constant, but varies within rather wide limits. Some of the changes are periodic, while others are spasmodic and irregular. The sunspot period appears to be in some way related to the changes in the earth's magnetic condition; for, at the time when the spots are at their maximum in number, the so-called magnetic storms are most frequent and violent. There is a general agreement among meteorologists that the magnetic changes observed upon the earth are in some obscure manner due to the influence of the sun.

In meteorology, as elsewhere, when other explanations are unavailable, resource is found in electricity, especially so if electrical phenomena can be in some manner discovered to be involved; and this happens to be the case in a very great number of phenomena, not as causes, but as effects. Not infrequently it happens that some of the best-known laws of electricity are ignored, or are confounded with other laws of other forms of energy. This seems to be precisely the case in this phenomenon.

In his article upon meteorology, in the last edition of the "Encyclopædia Britannica," Balfour Stewart says, "We are thus driven to look to the upper regions of the earth's atmosphere as the most probable seat of the solar influence in producing diurnal magnetic changes; and it need hardly be said that the only conceivable cause capable of operating in such regions must be an electric current. Now, we know from our study of the aurora that there are currents in such regions, continuous near the pole, and occasional in lower latitudes." And yet a little further on he argues very properly that more knowledge seems to be needed before we can assert that there are currents of electricity in regions where conduction is impossible.

Now, a current of electricity always implies conduction, and conduction implies molecular contact. We are abundantly able to prove this: for with such vacua as can readily be produced, say, the millionth of an atmosphere, not only will electricity not traverse it, but even Crookes's phenomena cease. At the height of a hundred miles, the average free path of the molecules is measured by feet; and this renders it as certain as any thing we know in physics, that electrical currents are impossible there, and hence, whatever may be the explanation of the magnetic changes in the earth, they are not due to currents of electricity in those high regions.

Still the earth is a magnet. It has its poles, though these change their position. The bulk of the earth with which we are acquainted is made up of non-magnetic matter, having varying degrees of conductivity; the rocky part being very poor, while the oceans and moist soils are conductors to such a degree as to permit commercial use for telegraphic and other purposes, thus saving the cost of a return conductor. The larger part of the surface of the earth is, then, an electrical conductor. Whenever a conductor of electricity is rotated in a magnetic field, an electrical current is the result; and such current is maintained so long as the rotation is continued, the strength of the current depending upon several variables, the strength of the magnetic field, the degree of conductivity, and the rate of rotation.

That electrical currents are continually traversing the crust of the earth, has been established, since the telephone has provided us with an instrument delicate enough for observation, and employed by so many all over the earth.

To be sure, it was known before that earth-currents were sometimes present, for upon occasions they were so strong as to interfere with or stop telegraphic communication. Such interruptions were generally coincident with auroral displays, but sometimes occurred in the day-time, when auroral effects could not be seen if they chanced to be present. As these earth-currents have been found to be coincident with both magnetic disturbances and with spasmodic solar action, — for several observers have noted solar eruptions at times when the magnetometers gave evidence of magnetic changes in the field, and in one or two cases even determining that the rate of transmission of the sun's action was the same as that of light, — it follows that the earth acts as if it were rotating in the magnetic field of the sun.

If the sun be considered as a magnet, then its field extends to an indefinite distance in space, and the earth must be rotating in it; and, so far as the earth is a conductor, there should be currents in it: in fact, just what we discover. So far, the electricity is an effect, and not a cause, magnetism being the preceding physical state.

A conductor moving in a magnetic field in such a manner as to have electrical currents generated in it always suffers retardation of its motion, as is illustrated by letting a coin fall between the poles of a strong magnet, — a property utilized in modern galvanometers to bring the needle quickly to rest. Such currents are technically known as "Foucault's currents," and the energy they represent is at once transformed into heat in the conductor. The electricity is but the transient state intermediate between the retarded motion and the rise in temperature. This series of physical relations — viz., the rotation of a conductor in a magnetic field, the retardation of the motion, the electrical current, and the final transformation into heat of original energy of the mechanical motion — is a well-ascertained series of effects, which is universal; and thus it follows, that, so far as the earth has currents of electricity set up in it by the sun's action, so far its rotary motion is retarded, and also its temperature is increased, both effects not hitherto recognized so far as I know. Of course, the retardation of motion is very small indeed, but it must be taking place, and in time will bring the earth to a standstill. What the amount may be, there appears to be no way of determining, because there is no way of ascertaining the strength of the earth's currents, nor the earth's resistance, nor the strength of the magnetic field of the sun.

Furthermore, the retardation of other bodies in the solar system may be traced to the same physical conditions instead of frictional resistance of the ether, which has sometimes been hypothesized.

Lastly, if the magnetic condition of the earth varies, it follows that the magnetic field of the earth varies, and all bodies in that field are re-acted upon by it. The gases of the atmosphere at high altitudes have free paths comparable with those in Crookes's tubes, and might fairly be expected to exhibit similar phenomena if electrified and in a changing magnetic field. Their electrification need not be much of an assumption, when one considers what happens in a thunder-shower. Rotating molecules, if conductors of electricity, ought to have Foucault's currents in them when in a magnetic field, and they should therefore be heated. As there is no chance for conduction of the heat, the rate of vibration increases till incandescence is reached. The only way in which the molecule can unload its extra energy is by radiation.

The motions seen in auroras may thus be due to the changes in the magnetic field of the earth instead of to electrical currents circulating in the high air.

A. E. DOLBEAR.

College Hill, Mass., April 23.

Chrome Yellow considered as a Poison.

THE object of this note is to spread wide the facts that chrome yellow is a poison, and that its use in food-stuffs is by no means rare.

The cases reported up to this time, in which toxic action is assigned to lead chromate and to chrome yellow, — bodies which apparently all writers consider as identical, — are many more than a hundred. Seemingly the first report is to be found in the *Medical Times and Gazette* of Dec. 24, 1859, in which are set forth the cases of six school-lads who were seriously poisoned by eating Bath buns. These latter were shown to contain each "seven grains of chromate of lead," which had been used as coloring-matter in lieu of eggs. All of the six lads are stated to have recovered.

In 1874, Von Linstow was next to assign toxic action to these bodies. He attributed to them the deaths of two children, within his own practice, who had eaten possibly seven artificial bees which had served to ornament a cake. Each of these bees had been colored by about four milligrams of "neutral lead chromate." The cause of death was destruction of the coats of the œsophagus and stomach, with puncturing of the intestines. The cases are reported in Eulenberg's *Vierteljahrsschrift f. ger. Med.*, N.F. XX., and

are mentioned as being a part of the literature of the subject. They are entirely discredited by the later work of Stewart, of Marshall, and of others, all of which will be mentioned later.

In 1882, R. C. Smith printed an account of more than fifty cases of poisoning among English mill-operatives who had breathed the dust of lead chromate given off from yellow dyed yarn in process of manufacture. The cases occurred in his own practice and in that of his co-workers, and authentication is complete. The effect was chronic lead-poisoning, clearly developed. This account, so important and interesting, is but a brief statement of bare fact. It is to be found in the *British Medical Journal*, 1882.

Five years before the publication of Dr. Smith's paper, Leopold (*Vierteljahrsschrift f. ger. Med.*, N.F. XXVII. 29) published an account of a babe which he stated had died from breathing lead-chromate dust from yellow dyed yarn. The cause of death is assigned to softening and perforation of the coats of the stomach, — an opinion to which Leopold, apparently, was bent by the cases of Von Linstow, already cited. As we now know quite surely that lead chromate is not at all a corrosive poison, we must so far discredit Leopold's case. In the same account he states that four adults who breathed the same dust incurred chronic lead-poisoning. He was therefore first to trace that kind of effect to the breathing of lead-chromate dust, and for that work we cannot offer him too much thanks.

The report of Smith is followed chronologically by the admirable work of Dr. D. D. Stewart of Philadelphia, the early history of which is to be found in the Philadelphia daily papers of July, 1887, and in the office of the coroner of that city. A few months previously, Dr. Stewart had found some cases of lead-poisoning, which, through tenacity of purpose, he finally traced to bakers' stuffs as the cause. He secured in a bakery the chrome yellow with which these stuffs had been colored, and showed that the baker himself was a physical wreck from eating his own wares; and, moreover, that several members of his family had died of lead-poisoning, brought about by eating the chrome-yellow colored stuffs. This latter was proven by the bodies exhumed by the coroner, who investigated altogether fifteen deaths. The work was done by Deputy Coroner Powers, who, in an interview at his office on Sept. 10, 1887, told the writer that it was a small estimate to put at two hundred the people in Philadelphia who had died of lead-poisoning induced by bakers' stuffs. The causes of death, he said, had been certified to various diseases, among them malaria and cerebro-spinal meningitis, but that now all physicians agreed that they were cases of lead-poisoning.

One who had examined the mortuary records informed the writer that others of these deaths were assigned to typhoid, typhus, epilepsy, Bright's disease, and to leptomeningitis. The real causes were established by Dr. Henry Leffmann, who analyzed the viscera of the exhumed bodies. The victims had died of lead-poisoning. During the coroner's investigations, it was shown that the use of chrome yellow by bakers as a coloring-matter was quite common. At an inquest held July 11, 1887, the evidence of Dr. Miller of the firm of Aschenbach & Miller, dealers in colors, was "that he believed that eighty per cent of the bakers in the city" used chrome yellow in certain of their bread-stuffs. In February of the following year, two of these bakers were sentenced to terms of imprisonment. The courts appear to have been lenient because the bakers themselves had been so distressed by the poisoning. One of them had lost a wife and five children, and was himself a wreck.

The discovery of the cause of so much suffering and death in Philadelphia is due to Stewart alone; and no less to him is due the action taken by the officers of the law towards the victims and the criminals.

The clinical history of Dr. Stewart's cases may be found in the *Medical News* of three dates: 1. June 1887, under the title "Notes on Some Obscure Cases of Poisoning by Lead Chromate;" 2. Dec. 31, 1887, "Clinical Analysis of Sixty-four Cases of Poisoning by Lead Chromate (Chrome Yellow) used as a Cake-Dye;" 3. Jan. 26, 1889, "Poisoning by Chrome-Yellow used as a Cake-Dye: A Subsequent Clinical History, etc." The literature of the subject has nothing at all comparable with these papers. In this field the author stands easily first among his brothers.

The chemical and pathological sides of the subject have lately

been worked out, with painstaking and in the scientific spirit, by John Marshall, M.D., of Philadelphia. His paper is to be found in the *Therapeutic Gazette* for Feb. 15 of the present year. His experiments were made upon dogs, to which he fed pure lead chromate in various quantities, up to eighty-four grams. Careful analyses were made of the products of decomposition going on in the living animals, and finally autopsies were performed upon their bodies. The experimenter found that lead chromate had been decomposed in the bodies of the living animals, and that lead and chromium had been absorbed, and that in all cases "the stomach showed no evidence of corrosion." This work of Dr. Marshall is altogether excellent. No epitome of it could do it justice, and of course the workers in this field will read the original paper. It is proof positive that lead chromate could have produced all the effects which Stewart insists it did produce, in his cases.

The work so well done by Marshall suggested itself to the present writer at the time of the newspaper publication of Stewart's cases, and dogs were selected for the experiments. But it was put a stop to by two discoveries: (1) that the writer did not possess the knowledge requisite, and (2) that chrome yellow of commerce was not lead chromate. This latter discovery arose out of the analyses of various samples from many manufacturers, a few of the results being as follows:—

No. of Sample.	Lead Chromate.	Lead Sulphate.	White Lead.	
1	66.38	28.83	x	Samples analyzed as received, and no account taken of moisture.
2	32.52	18.82	47.04	
3	60.77	11.90	24.38	
4	14.47	20.81	60.95	
5	58.10	36.24	x	
6	26.79	68.84	x	

No. 1 was obtained in open market, and bore the name of distinguished manufacturers. It was marked "Pure Precipitated."

No. 2 was given the writer by Dr. Henry Leffmann, before mentioned. It was part of a sample submitted by the coroner of Philadelphia to his jury sitting upon one of the poisoning cases unearthed by Stewart.

Nos. 3, 5, and 6 were from a manufacturing chemist in Baltimore who wanted pure lead chromate, and who undertook to obtain it from among his correspondents. These three samples were certified as perfectly pure.

No. 4 was given the writer by Dr. Miller, from out of the stock of Messrs. Aschenbach & Miller, who as merchants were concerned in the Philadelphia chrome-yellow cases. It was kindly submitted as being of the kind used by the bakers concerned in Stewart's cases.

The samples given in the above table are selected as being typical of good commercial chrome yellow. Efforts continued through nearly a year did not result in finding a single sample of lead chromate sold as chrome yellow.

Having ascertained that commercial chrome yellow consisted of lead chromate with lead sulphate, and with white lead frequently, it followed that such a compound could produce lead-poisoning, and certainly would if taken into the stomach during any length of time. There could not exist, therefore, any doubt as to the correctness of the views of Stewart, so far as concerned the source of poisoning.

Shortly after newspaper publication of the Philadelphia cases, the writer bought and examined in Baltimore several samples of yellowish bakers' stuffs. None of them contained lead. But there was no such result with certain kinds of candy. There was to be had in two of the Baltimore public markets an abundance of candy made from glucose, and colored by chrome yellow. With the view of stopping its sale, one of the city papers agreed to collect candy samples by means of its reporters, and cause them to be analyzed. This was done, and on the first day of search five samples were bought in two of the markets. Four of the five contained chrome yellow in quantity from 0.199 per cent to 0.319 per

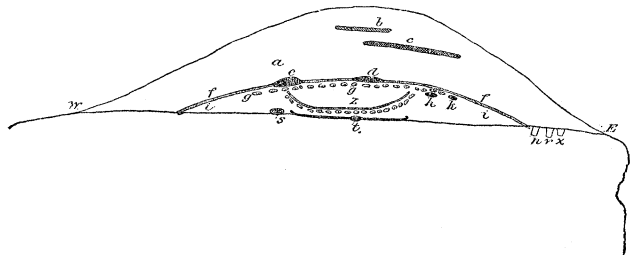
cent. The analyses are to be found in the *Baltimore American* of April 22, 1888, and are signed by the writer and his co-worker, Dr. William Simon. Both of us had repeatedly bought in the markets, and together had analyzed, similar candy with the same results. The quantity sold in a market on a market-day apparently was not less than ten nor more than thirty pounds. We have preserved samples of the material, and shall be glad to divide them with workers in this field. Such candy, consumed in such quantities, cannot have failed to produce in Baltimore an abundance of lead-poisoning.

From all this we deduce the following conclusions: that lead chromate breathed as dust, or taken into the digestive apparatus, produces lead-poisoning; that commercial chrome yellow ingested with food-stuffs produces more quickly the same result; that chrome yellow is a mixture of lead chromate and lead sulphate, to which frequently is added white lead ($2 \text{ Pb CO}_3 + \text{Pb H}_2\text{O}_3$); that none of these substances are corrosive poisons; that bakers' and confectioners' products not infrequently are colored with chrome yellow, and often are sources of lead-poisoning, which may exist largely in a community and yet escape detection. WM. GLENN.

Baltimore, April 26.

A Mound in Calhoun County, Ill.

MR. MIDDLETON, one of the assistants of the Bureau of Ethnology, has recently excavated quite a number of mounds in Calhoun County, Ill., among them one presenting some features of special interest. The following description is taken from Mr. Middleton's field-notes.



This mound, which forms one of a group of five located on the spur of a bluff about one hundred and fifty feet high, overlooking the Illinois River, stands at the brink of a precipice. It is conical in form, and ninety-five feet in diameter at the base.

As the internal structure is the most interesting feature, a figure is given showing a vertical section, in which *W-E* indicates the line of the natural surface of the bluff, as well as the direction of the section.

"From the top downward to the depth of fourteen feet," says Mr. Middleton, "we passed through a layer composed chiefly of yellow clay (*a*) obtained from the surrounding surface of the bluff. Near the centre, at the depth of four feet, was a horizontal bed (*b*) of hard gray earth, — apparently muck from the river, — eight inches thick, and covering an area about twenty feet in diameter. Three feet lower was a bed (*c*) of burnt clay about the same thickness and extent as the preceding. Although particles of charcoal were mixed through it, no ashes were observed on or about it.

"At the depth of fourteen feet we reached what seems to have been the nucleus or original mound, over which the heavy mass of clay had been cast at some subsequent period. Over this lay a thin covering of whitish material (*f, f*), apparently light ashes, not more than two inches thick, and extending on all sides to the original base. This rested, for the most part, on a single layer of stones (*g, g*), the latter lacking several feet of extending to the outer margin. Examining carefully the stones which formed this layer, evidences of weathering on the upper side were distinctly visible, showing that the mound must have remained undisturbed at this height for a considerable length of time. The thin stratum of ashes over it seems to confirm this view, as the charred stems of grass near the outer margin show that this was produced by burning a covering of grass which had grown over it. The dark spots (*d* and *e*) indicate two small fire-beds resting on the layer of stones.

"Removing the stones, and cutting a trench through the low, broad, original mound or nucleus to the natural surface of the bluff, we found the construction to be as shown in the figure, — an oval basin (*z*), ten by thirteen feet in extent and three feet deep, lined throughout with a layer of stones similar to those above. It was filled with the yellow surface soil of the ridge. The stones, which bore very distinct marks of weathering, were covered with a thin layer of white ashes mixed with charred leaves and grass. Under the stones, and resting on the natural surface of the ridge, was a thin layer of decayed vegetable matter. The slopes (*i-i'*) surrounding the basin were of yellow clay similar to that of the thick upper layer of the mound. The dark spots (*h* and *h'*) are small fire-beds.

"Partly under and partly in the bottom layer of decayed vegetable matter, and exactly in the centre of the mound, was a single skeleton (*t*) lying on the back at full length, the feet to the south; but the head was wanting. Not a tooth, or particle of the jaw or skull, was to be found, though careful search was made. As all the other bones were well preserved and comparatively sound, except that the pelvis and some of the ribs were broken, I presume the head must have been removed before burial. This is the second instance I have observed in which the head was removed before burial. The first was dug up at Pecan Point, Arkansas.

"Six feet south of the centre of the mound was a small deposit of burned bones (*s*), lying on the natural surface of the bluff. Seven feet west of the centre, lying on the original soil, were the remains of an infant. It had been doubled up until the knees touched the chin, wrapped in a grass covering, and placed upon its left side.

"A shell-shaped vessel at the right shoulder of the large skeleton, and a shell, were the only specimens found in the mound. The latter was in a stone box or cist two feet and a half square and one foot deep, resting on the natural surface of the ridge. Not a fragment of bone was found in this box.

"Another singular feature observed consisted of three small pits (*n, v, x*) under the eastern base of the upper layer. These were three holes, from fifteen to eighteen inches in diameter, and one foot deep. One of them contained particles of rotten wood. There were several intrusive burials in the thick upper clay layer, which presented nothing of special interest."

It is apparent, from Mr. Middleton's figure and description, that we have in this tumulus a specimen of the Ohio "altar-mound" type, possibly a prototype. What he calls the nucleus or original mound is beyond question one of the so-called "altars" of the type described by Messrs. Squier and Davis, and is one more item of evidence that the Ohio mound-builders came from the West, as I have contended elsewhere.

CYRUS THOMAS.

Washington, D.C., April 23.

New Sources of Heat.

IF, as I take it, the communication of your correspondent "X," on p. 329 of your issue of April 26, is intended as a sort of exposure, it is to be warmly welcomed.

What Mr. Blodget has actually done, I cannot say; but that his assertions are extremely inaccurate, I know. He states that "in all cases where a powerful blast is applied to the limited area of a melting-furnace . . . the degree of heat generated is greatly in excess of the theoretical yield of the number of pounds of coal consumed." This is absolutely untrue. On the contrary, measurements of the heat actually developed under these conditions agree surprisingly closely with the "theoretical yield of the number of pounds of coal consumed." This is well exemplified in Bell's calculations and measurements of the heat developed in the blast-furnace.

Mr. Blodget's statement that this excess of heat generated over the theoretical yield of the coal is particularly great in the Bessemer converter, is a case of astonishing ignorance, or, as I prefer to believe, of extreme carelessness in the use of words. I supposed that every reader of *Science* knew that no carbonaceous fuel was burned in the Bessemer converter (except, of course, in heating the converter between operations). A new Keely motor seems to be born. *Caveat emptor.*

HENRY M. HOWE.

Boston, April 29.